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PATENT SPECIFICATION 834,135

DRAWINGS ATTACHED.

Inventor :—PETER BRYAN CURTIS.

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COMPLETE SPECIFICATION.

Improvements in or relating to Pyrometric Apparatus.

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C.2, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement :—

This invention relates to pyrometric apparatus. More particularly the invention is concerned with pyrometric apparatus for measuring the temperature of a surface or space and including means for transmitting thermal radiation from the surface or space to a heat-sensitive device such, for example, as a thermopile. One object of the present invention is to provide improved apparatus of this type which may be applied to the measurement of the surface temperature of a workpiece which is being heat-treated by high frequency induction heating.

According to the present invention, in pyrometric apparatus for measuring the temperature of a surface or space and including an elongated member for transmitting thermal radiation from the surface or space to a remote heat sensitive device, said member being of transparent material, as hereinafter defined, and being shaped at one end to provide an end face adapted to be disposed adjacent to the surface, or within the space, and shaped at its other end so as to direct radiation transmitted by the member onto the heat sensitive device, the surface of the member between its ends is provided with reflection means to avoid leakage of radiation from this surface and to enable it to transmit thermal radiation from one end to the other without substantial loss.

By transparent material is meant a material which transmits thermal radiation ; thus the member may be of quartz. The surface of the member between the ends may be protected by an envelope attached to the member adjacent to the first-mentioned end.

Where the apparatus is for use in measuring the temperature of a surface being heat-treated by high frequency induction heating, there being an induction coil of elongated cross-section disposed close to the surface, the end of the member adapted to be disposed adjacent to the surface may be of flattened cross-section and adapted to protrude through the induction coil.

In order that the invention may be fully understood, one construction of pyrometric apparatus in accordance with the present invention, suitable for use in the measurement of the surface temperature of a workpiece undergoing heat-treatment by high frequency induction heating, will now be described by way of example, with reference to the accompanying drawing which shows a perspective view of the apparatus.

Referring to the drawing, the apparatus comprises essentially a heat-sensitive, that is to say a temperature measuring device which in the present example is a thermopile, and means for directing thermal radiation from the surface whose temperature is to be measured onto this device. The thermopile has a number of hot junctions and a number of cold junctions connected in series, and is mounted within a substantially closed cavity constituted by a cylindrical housing the walls of which are of heat conducting material. The housing is formed in three parts, these being a cylindrical wall member 1 and two end wall members. One end wall member 2 consists of a boss projecting from one side of a flanged member and this boss is adapted to engage in a recess

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in one end of the cylindrical wall member, the latter being bolted to the flanged member by means of three bolts passing through holes in the wall of the cylindrical member which are parallel to its axis. The other end wall member 3 is bolted to the other end of the cylindrical member. The thermopile is mounted between the two members 1 and 2 in the manner described in the Complete Specification accompanying co-pending Patent Application No. 4125/57 (Serial No. 834,134), and paxolin supports 4 for electrical connections from the thermopile are housed in diametrical slots formed in the co-operating faces of the members 1 and 3; a pair of current leads 5 connecting the thermopile to a galvanometer or other suitable measuring device pass through a further slot 6 at the end of the cylindrical member 1.

A second boss (not shown) having a screw thread is carried on the flanged member on the opposite side from the first-mentioned boss and coaxial therewith. A cylindrical hole passes axially through the flanged member, and a quartz rod 7 constituting the means for directing radiation onto the hot junctions extends through this hole, into the cavity. The end of the rod 7 inside the cavity is shaped to provide a converging lens which focusses radiation transmitted by the rod onto the hot junctions.

The cold junctions of the thermopile are clamped onto the walls of the cavity so as to be in close thermal contact therewith; they are electrically insulated from the walls, however, by means of thin mica washers. It will be seen that since the cavity is substantially closed there can be practically no temperature gradient between two parts of the cavity, and so the electromotive force generated by the thermopile, due to thermal radiation falling upon the hot junctions, is dependent solely upon the amount of this radiation and is independent of the temperature of the housing. This applies, of course, only within a predetermined range of temperature which range is determined by the characteristics of the thermojunctions.

The quartz rod 7, which is cylindrical for the greater part of its length, is of flattened cross section towards its end remote from the thermopile, increasing in width and decreasing in thickness towards the end. This end is ground to provide a flat end face 8 which is inclined slightly to the axis of the rod. An envelope 9 of quartz enclosing the rod 7 is fused at one end onto the flattened portion of rod, this envelope serving to protect the surface of the rod from contaminating materials which would impair the reflecting properties of the surface. The other end of the envelope is formed with a circular flange (not shown) which is clamped onto the face of the screw-threaded boss by means of a screw-threaded collar 10, a gasket of paxolin between the flange and the face of the boss serving to effect a good seal. The outer surface of the envelope 9 is silvered over that portion of the envelope which is joined to the rod.

The apparatus described is particularly suitable for the measurement of the surface temperature of a workpiece undergoing heat-treatment, such as surface hardening, by high frequency induction heating. In such treatment, and especially if the workpiece be cylindrical, it is common to have an induction coil of elongated cross section disposed in close proximity to the surface of the workpiece, the workpiece being rotated slowly about an axis and the induction coil being arranged parallel to this axis. As the workpiece rotates, that portion of the surface which has been heated is quenched by cooling oil. In order to measure the temperature of the surface as it passes under the coil, the apparatus is bolted onto a frame supporting the coil by means of clamping bolts which pass through holes in the flange of the flanged member, the end of the quartz rod protruding through the coil with its ground end face in close proximity to the surface and parallel to it. Thermal radiation, the intensity of which is dependent upon the temperature of the surface beneath the coil, is emitted by the surface and passes through the end face of the rod. This radiation is transmitted by the rod without substantial loss along its length and is focussed onto the hot junctions of the thermopile, the shape of the rod being such that any of the transmitted radiation impinging upon its surface does so at an angle which is greater than the critical angle and is therefore totally reflected.

Contamination of the surface of the rod by oil, which would impair its reflecting properties, is prevented by the envelope. In an alternative construction, instead of having a protecting envelope, such as 9, however, the surface of the rod may be silvered along its entire length.

The apparatus is also suitable for measuring the temperature of the melt in a bath of molten metal, such as aluminium; for this purpose the end of the quartz rod would be submerged in the metal and the temperature measured by the apparatus would be that of the metal adjacent to the ground end face.

WHAT WE CLAIM IS:—

1. Pyrometric apparatus for measuring the temperature of a surface or space and including an elongated member for transmitting thermal radiation from the surface or space to a remote heat sensitive device, said member being of transparent material, as hereinbefore defined, and being shaped at one end to provide an end face adapted to be disposed adjacent to the surface, or within the space, and shaped at its other end so as

to direct radiation transmitted by the member onto the heat sensitive device, wherein the surface of the member between its ends is provided with reflection means to avoid leakage of radiation from this surface and to enable it to transmit thermal radiation from one end to the other without substantial loss.

2. Pyrometric apparatus as claimed in Claim 1, wherein a protecting envelope is attached to the member adjacent to the first-mentioned end.

3. Pyrometric apparatus as claimed in Claim 2, wherein the outer surface of the protecting envelope is silvered over that portion of the envelope which is joined to the elongated member.

4. Pyrometric apparatus as claimed in Claim 1, wherein the surface of the elongated member is silvered along its length.

5. Pyrometric apparatus as claimed in any preceding claim, and adapted for use in measuring the temperature of a surface being heat-treated by high frequency induction heating, there being an induction coil of elongated cross-section adapted to be disposed close to the surface, wherein the end of the member adapted to be disposed adjacent to the surface is of flattened cross-section and adapted to protrude through the induction coil.

6. Pyrometric apparatus substantially as hereinbefore described with reference to, and as illustrated in, the accompanying drawing.

For the Applicants :

F. S. PEACHEY,

Chartered Patent Agent.

PROVISIONAL SPECIFICATION.

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This invention relates to pyrometric apparatus. More particularly the invention is concerned with pyrometric apparatus for measuring the temperature of a surface or space and including means for transmitting thermal radiation from the surface or space to a heat-sensitive device such, for example, as a thermopile. One object of the present invention is to provide improved apparatus of this type which may be applied to the measurement of the surface temperature of a workpiece which is being heat-treated by high frequency induction heating.

According to the present invention, in pyrometric apparatus for measuring the temperature of a surface or space and including means for transmitting thermal radiation from the surface or space to a remote heat-sensitive device, the said means comprise an elongated member shaped at one end to provide an end face which is adapted to be disposed adjacent to the surface, or within the space, and shaped at the other end so as to direct radiation transmitted by the member onto the heat-sensitive device, the member being of transparent material and adapted to transmit thermal radiation from one end to the other without substantial loss.

By transparent material is meant a material which transmits thermal radiation ; thus the member may be of quartz. In order to avoid leakage of radiation from the surface of the member between the ends, this surface may be silvered. Alternatively, the member may be so shaped that, over the greater part of its length, radiation impinging upon the surface does so at an angle greater than the critical angle. The surface of the member between the ends may be protected by an envelope attached to the member adjacent to the first-mentioned end.

Where the apparatus is for use in measuring the temperature of a surface being heat-treated by high frequency induction heating, there being an induction coil of elongated cross-section disposed close to the surface, the end of the member adapted to be disposed adjacent to the surface may be of flattened cross-section and adapted to protrude through the induction coil.

One form of pyrometric apparatus in accordance with the present invention, suitable for use in the measurement of the surface temperature of a workpiece undergoing heat-treatment by high frequency induction heating, will now be described by way of example.

The apparatus comprises essentially a temperature measuring device which in the present example is a thermopile, and means for directing thermal radiation from the surface whose temperature is to be measured onto this device. The thermopile has four hot junctions and four cold junctions connected in series, and is mounted within a substantially closed cavity constituted by a cylindrical housing the walls of which are of heat conducting material. The housing is formed in three parts, these being a cylindrical wall member and two end wall members. One end wall member consists of a boss projecting from one side of a flanged member and this boss is adapted to engage

in a recess in one end of the cylindrical wall member, the latter being bolted to the flanged member by means of three bolts passing through holes in the wall of the cylindrical member which are parallel to its axis. The other end wall member is bolted to the other end of the cylindrical member. Paxolin supports for the thermopile are housed in diametrical slots formed in the co-operating faces of these two members, and a pair of current leads connecting the thermopile to a galvanometer or other suitable measuring device pass through a further slot at the end of the cylindrical member.

A second boss having a screw thread is carried on the flanged member on the opposite side from the first-mentioned boss and coaxial therewith. A cylindrical hole passes axially through the flanged member, and a quartz rod constituting the means for directing radiation onto the hot junctions extends through this hole, into the cavity. The end of the rod inside the cavity is shaped to provide a cylindrical lens which focusses radiation transmitted by the rod onto the hot junctions.

The cold junctions of the thermopile are clamped onto the walls of the cavity so as to be in close thermal contact therewith; they are electrically insulated from the walls, however, by means of thin mica washers. It will be seen that since the cavity is substantially closed there can be practically no temperature gradient between two parts of the cavity, and so the electromotive force generated by the thermopile, due to thermal radiation falling upon the hot junctions, is dependent solely upon the amount of this radiation and is independent of the temperature of the housing. This applies, of course, only within a predetermined range of temperature which range is determined by the characteristics of the thermojunctions.

The quartz rod, which is cylindrical for the greater part of its length, is of flattened cross-section towards its end remote from the thermopile, increasing in width and decreasing in thickness towards the end. This end is ground to provide a flat end face which is inclined slightly to the axis of the rod. An envelope of quartz enclosing the rod is fused at one end onto the flattened portion of rod, this envelope serving to protect the surface of the rod from contaminating materials which would impair the reflecting properties of the surface. The other end of the envelope is formed with a circular flange which is clamped onto the face of the screw-threaded boss by means of a screw-threaded collar, a gasket of paxolin between the flange and the face of the boss serving to effect a good seal. The outer surface of the envelope is silvered over that portion of the envelope which is joined to the rod.

The apparatus described is particularly suitable for the measurement of the surface temperature of a workpiece undergoing heat-treatment, such as surface hardening, by high frequency induction heating. In such treatment, and especially if the workpiece be cylindrical, it is common to have an induction coil of elongated cross-section disposed in close proximity to the surface of the workpiece, the workpiece being rotated slowly about an axis and the induction coil being arranged parallel to this axis. As the workpiece rotates, that portion of the surface which has been heated is quenched by cooling oil. In order to measure the temperature of the surface as it passes under the coil, the apparatus is bolted onto a frame supporting the coil by means of clamping bolts which pass through holes in the flange of the flanged member, the end of the quartz rod protruding through the coil with its ground end face in close proximity to the surface and parallel to it. Thermal radiation, the intensity of which is dependent upon the temperature of the surface beneath the coil, is emitted by the surface and passes through the end face of the rod. This radiation is transmitted by the rod without substantial loss along its length and is focussed onto the hot junctions of the thermopile, the shape of the rod being such that any of the transmitted radiation impinging upon its surface does so at an angle which is greater than the critical angle and is therefore totally reflected.

Contamination of the surface of the rod by oil, which would impair its reflecting properties, is prevented by the envelope. Instead of having a protecting envelope, however, the surface of the rod may be silvered along its entire length.

The apparatus is also suitable for measuring the temperature of the melt in a bath of molten metal, such as aluminium; for this purpose the end of the quartz rod would be submerged in the metal and the temperature measured by the apparatus would be that of the metal adjacent to the ground end face.

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F. S. PEACHEY,
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1 SHEET

COMPLETE SPECIFICATION

This drawing is a reproduction of the Original on a reduced scale.